Markowitz efficient frontier states investors should consider multiple securities in a portfolio rather than individually. A portfolio that contains combination of securities with low correlation can benefit from a diversification effect. Meaning investors can optimize their return without assuming additional risk. Markowitz

In [5]:
```
import numpy as np
import pandas as pd
from pandas_datareader import data as web
import matplotlib.pyplot as plt
%matplotlib inline
```

WE will download the data on PG stock and ^GSPC

In [2]:
```
tickers = ["PG", "^GSPC"]
data = pd.DataFrame()
for t in tickers:
    data[t] = web.DataReader(t, data_source = "yahoo", start = "2010-1-1")["Adj Close"]
```

In [4]:
```
#normalize the data
(data/data.iloc[0]*100).plot(figsize = (16,8))
plt.show()
```

Calculate the daily change, returns of both securties

In [51]:
```
simple_returns = (data/data.shift(1)) - 1
```

In [52]:
```
#we will check if the data matches and have equal values - > 2494 PG and 2494 ^GSPC
simple_returns.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 2495 entries, 2010-01-04 to 2019-11-29
Data columns (total 2 columns):
PG       2494 non-null float64
^GSPC    2494 non-null float64
dtypes: float64(2)
memory usage: 58.5 KB
```

In [53]:
```
#check the tail end of the data to check for most current date
simple_returns.tail()
```

Out[53]:

Date	PG	^GSPC
2019-11-22	-0.000415	0.002175
2019-11-25	0.001829	0.007507
2019-11-26	0.014522	0.002196
2019-11-27	-0.004090	0.004174
2019-11-29	0.002464	-0.004011

In [11]:
```
simple_returns.cov() * 250
```

Out[11]:

	PG	^GSPC
PG	0.021868	0.011354
^GSPC	0.011354	0.021763

In [54]:
```
#the correlation between PF and ^GSPC is positive but low so the portfolio should benefit from
#markowitz diversification effect
simple_returns.corr()
```

Out[54]:

	PG	^GSPC
PG	1.000000	0.520464
^GSPC	0.520464	1.000000

In [57]:
```
# portfolio optimization -> We will need the count of securities in the portfolio
port_asset = len(tickers)
print(f"The number of securties in the portfolio is {port_asset}")
```

```
The number of securties in the portfolio is 2
```

WE will need the expected returns and the volatility to simulate a mean variance combination with 1000 simulations. WE are considering 1000 combinations of the same 2 assets of their weight values not 1000 different investments.

In [ ]:

In [58]:
```
#Bellow we will run a simulation of 1000 differenct portfolio that conta
in PG and ^GSPC to test Markowitz theory.
#This Will provide us with both 1000 different expected returns and 1000
volatility values

portfolio_returns = []
portfolio_volatilities = []

for x in range(1000):
    weights = np.random.random(port_asset)
    weights /= np.sum(weights)
    portfolio_returns.append(np.sum(weights * simple_returns.mean()) * 2
50)
    portfolio_volatilities.append(np.sqrt(np.dot(weights.T, np.dot(simpl
e_returns.cov() * 250, weights))))

    # we will need to convert the volatilities and and the ezpected retu
rns into a numpy array
port_Returns = np.array(portfolio_returns)
port_Vol = np.array(portfolio_volatilities)
```

In [ ]:

In [ ]:

In [60]:
```
#lets create a data fram containing the data
portfolios = pd.DataFrame({"Returns": port_Returns, "Volatility": portfo
lio_volatilities})
```

In [61]:
```
portfolios.head()
```

Out[61]:

	Returns	Volatility
0	0.112761	0.132366
1	0.112363	0.129450
2	0.112482	0.128782
3	0.112670	0.130430
4	0.112502	0.128800

In [62]:
```
portfolios.tail()
```

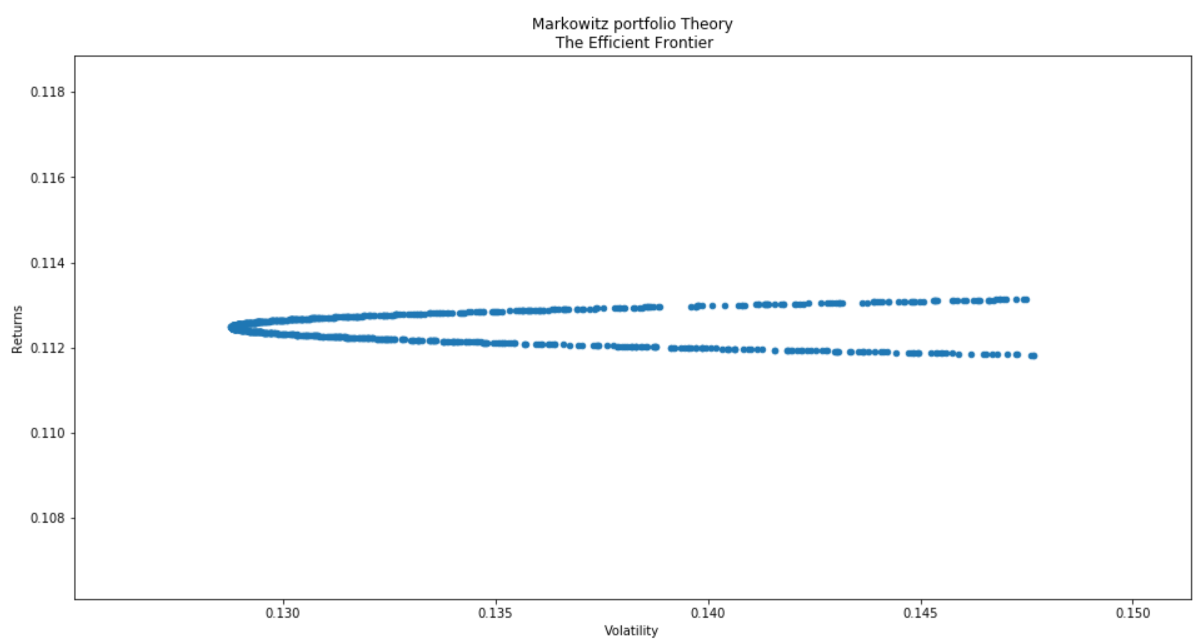
Out[62]:

	Returns	Volatility
995	0.112449	0.128836
996	0.112493	0.128787
997	0.112543	0.128953
998	0.112838	0.134600
999	0.112159	0.133605

In [63]:
```
portfolios.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 2 columns):
Returns       1000 non-null float64
Volatility    1000 non-null float64
dtypes: float64(2)
memory usage: 15.7 KB
```

In [66]:
```
portfolios.plot(x ="Volatility", y ="Returns", kind = "scatter", figsize
= (16,8))
plt.title("Markowitz portfolio Theory\n The Efficient Frontier")
plt.show()
```



THe above graph shows a set of 1000 portfolios of different weights containing PG & ^GSPC, and displays the typical shape of Markowitz efficient portfolio. There are a set of efficient portfoilios that can provide a higher rate of return for the same or lower risk. The starting point is the minimum variance portfolio.